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ABSTRACT

The purpose of this experiment was to examine lag function developmental parameters and to test a related developmental hypothesis and the predictions it generated. Fourth and eighth graders and adults were shown a series of words, one at a time, with some words presented twice. Between the two presentations of each repeated word there was one of three lag conditions: no lag (Lag 0), short lag, or long lag. Items that were not repeated were labelled 1P words and used as a recall baseline. Subjects, tested individually, were given up to two minutes for written recall. Results showed highly significant lag effects for each age. Two predictions were supported: (1) that young children's recall would increase significantly between Lag 0 and short lag while older subjects' recall would not, and (2) that the older subjects' recall would show a major increase between short and long lag words while younger children's would not. No significant differences between 1P and Lag 0 recall levels were evident at any grade, suggesting that the number of retrieval cues for Lag 0 and 1P terms is identical. It is proposed that the paradigm suggested in this study might be used to explore developmentally the encoding processes used for pictures, words and other stimuli in recognition and recall tasks, and to test Maccoby's proposal that children are not as efficient as adults in using information available in the task to aid performance. The paradigm is currently being used to study how motivational variables affect encoding strategies. (GO)

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A DEVELOPMENTAL EXPLORATION OF THE EFFECTS OF SPACING ON THE RECALL OF REPEATED WORDS

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A DEVELOPMENTAL EXPLORATION OF THE EFFECTS OF SPACING ON THE RECALL OF REPEATED WORDS

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It is well established in the adult literature that free recall of a word presented twice increases linearly as the lag, or the number of words between the first and second presentation, increases. Researchers have suggested several theoretical explanations for lag phenomena; we will be looking at one of these. The purpose of our experiment was to examine lag function developmental parameters and to test a related developmental hypothesis and the predictions it generated. Finally, we will suggest how this paradigm could be used to assess developmental differences in processing strategies.

Tzeng in 1973 proposed that word repetition leads to better recall only after the first representation is no longer being actively processed in short-term memory. Why should this be the case? In the cue dependent memory hypothesis, presented by Melton (1970), recall probability is a function of the number of retrieval cues stored with a word; the more retrieval cues, the better the chances are for recall. For this view to account for lag effects, as more words intervene between same item presentations, the number of different encodings available for repeated items must increase. It can be assumed, then, that if a word is still in the buffer of short-term memory when it is repeated, the probability of different encoding for that word is small; the subject is likely to repeat the first encoding. A different encoding is more likely to occur when a word's first representation is no longer in buffer upon its second presentation because of buffer capacity limitations in short-term memory. The utility of lag, therefore, is defined as a joint function of buffer capacity and

the number of words intervening between test item repetitions during presentation.

Since buffer capacity in short-term memory would seem to determine recall probabilities at various lags in this account, deviations from typical adult short-term memory capacity should result in changing the nature of the lag function in predictable ways. The number of items rehearsed in buffer is one index of short-term memory capacity. Using an overt rehearsal procedure, Ornstein and Liberty (1973) reported data clearly indicating developmental differences in buffer capacity; third grade children rehearsed only one or two words at a time, while eighth graders were actively processing four or five. Words, on the average, were out of short-term memory more quickly for younger children than for older subjects.

The Ornstein and Liberty findings, in conjunction with the explanation for lag effects stated earlier, suggest several hypotheses. First, it was predicted that younger children's recall would significantly increase at a short lag while older subjects' recall would not, using recall of items shown twice in succession as the baseline for each grade level. This was expected because younger children have a small buffer capacity and the first representation would be out of buffer, even at a short lag, resulting in a high probability of generating a different encoding, facilitating recall. Older subjects with larger buffer capacity, on the other hand, would still be processing the item being presented again at a short lag, leading to no new encoding and thus no increase in recall. Significant increases would be anticipated only at a longer lag for these subjects, when it is more likely that the word is out of buffer upon second presentation. At this longer lag for young children, critical conditions are the same as they were at short lag; the second presentation takes place after the word is no longer in

buffer. A second hypothesis, then, was that there would be no improvement in recall between short and long lag words for younger children, but a major increase for older subjects would appear.

Method

Fourth and eighth grade children, and adults, 12 of each sex in each age group, were shown one list of words, with an item presented on a slide every five seconds. The basic list structure and one of the word lists used in the experiment are presented in Table 1. Four of the words presented twice were seen

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Insert Table 1 about here

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back to back, the Lag 0 condition; positions 15 and 16, with wood in both positions, is an example. Four repeated items were seen with two words intervening between presentations, the short lag or Lag 2 condition; book, in positions 21 and 24 is an example. Four words with eight items intervening between presentations were labeled Lag 8, or the long lag condition; smile, in list positions 4 and 13 is an example. Four of the items presented only once were labeled 1P words, used as a recall baseline. The remaining ten words were assigned to buffer and filler positions in the list and were not scored in the recall data. None of the 1P or repeated words appeared in the first three or final five list positions as a control for primacy and recency recall biases. Within each of the four sections labeled in Table 1, a list position was reserved for the second presentation of one item in each lag condition and for one 1P item to insure an equal distribution of words in each condition throughout the list. For example, in Section I, list positions 8, 9, and 13 contain the second presentation of the first Lag 0, Lag 2, and Lag 8 items, respectively; position 11 contains the first 1P item. Across subjects, with the exception of buffer and filler items, whose

positions remained constant, words were counterbalanced so that each appeared equally often as a 1P, or a Lag 0, Lag 2, or Lag 8 item. Subjects, tested individually, were given up to two minutes for written recall.

Results and Discussion

With Sex between, and Lag within subjects, a two factor mixed analysis of variance was performed for each of the three grade levels to test our experimental hypotheses. Highly significant lag effects were found at each age, permitting individual comparisons between critical lag conditions. Table 2 summarizes predictions and obtained t-test results.

Insert Table 2 about here

The first thing to note is that there were no significant differences between 1P and Lag 0 recall levels at any grade; back to back repetition led to recall levels no better than for words presented once. Our conceptual framework would predict that multiple encoding is highly unlikely for Lag 0 words because the first representation is still in short-term memory when repetition occurs at any age -- as many retrieval cues are generated for Lag 0 as for 1P items. Recall, being dependent on the number of cues encoded, is at the same level for both conditions.

Next, let's turn our attention to the lag data, starting with the youngest sample, Grade 4. We predicted a significant increase in recall between Lag 0 and Lag 2, and we obtained that result. Since children of this age have a small buffer capacity, as demonstrated by Ornstein and Liberty, there was a high probability that multiple encoding would take place for Lag 2 items because the second presentation of an item would occur after encoding of the first representa-

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tion was complete. We have already stated that multiple encoding was not likely for Lag 0 items; the difference in multiple encoding probability accounts for the observed increases.

We expected no increase between Lags 2 and 8 for the fourth graders; the data confirm this prediction as well. The probability for multiple encoding is as high at Lag 8 as at Lag 2. Why? The conditions are the same for each type of item; the second presentation occurs after the word is no longer in buffer. If there is no difference in multiple encoding probabilities, there is no reason to suspect differences in recall; there was no significant difference.

Except for recall levels, the eighth grade and adult lag functions share the same attributes and will be discussed together. Comparison of recall levels at Lags 0 and 2 showed no significant increase between these conditions for either group -- the predicted outcome. The reason is that, for these subjects, repetition at Lag 2 was functionally the same as a Lag 0 repetition. In both cases, the repetition of a word leads to no new encoding because the item's first representation is still in buffer. Recall levels were the same because no more encodings were available for Lag 2 words than for Lag 0 items.

A final result consolidates this developmental picture of word processing. The increase between Lags 2 and 8 was significant for each of the two older groups. At Lag 8, then, words were out of buffer by the time they were repeated, leading to the increase shown. Multiple encoding, not yet reliably occurring at Lag 2, finally occurs at Lag 8. Buffer capacity for the older subjects, while larger than that of fourth graders, is not unlimited.

A further observation supports the argument being advanced here. For the younger children, recall doubled between 1P and Lag 2, while for the older subjects,

recall doubled between 1P and Lag 8. This suggests again that items were out of buffer by Lag 2 for younger children with a probability similar to the likelihood that items were out of buffer at Lag 8 for the older subjects.

There are several implications stemming from this research. First, we propose that this paradigm can be used to explore developmentally the encoding processes used for pictures, words, and other stimuli in recognition and recall tasks. Several other paradigms have been used for this purpose. One, the overt rehearsal procedure, has its limitations; it may lead subjects to strategies not typically used because of the task demands. The observed processing may be a combination of the experimental task and the overt rehearsal requirement. At best, overt rehearsal is a slightly distorted reflection of what is done covertly. The repetition - or lag - paradigm may be a more subtle technique in which to explore developmental encoding strategies; the paradigm puts no additional "task demand" on the subject, as overt rehearsal does. This experiment has demonstrated the paradigm's sensitivity to buffer capacity, a critical component in the processing of information. It was shown by lag functions that fourth graders were typically holding less than three items in buffer, while older subjects held somewhere between 3 and 8 items.

A second, more general, usage may be to test a suggestion made by Maccoby (1969), who proposed that children were not as efficient as adults in using information available in the task to aid performance. By manipulating repetition at various lags, context could be experimentally changed around two presentations of to-be-remembered stimuli. Older subjects, who would be more sensitive to the contexts and their usefulness as retrieval cues, should show greater increases in recall than younger children, using recall of items shown once as a baseline. Developmental differences in recall may be partially explained in this way.

The developmental lag effects found in this study could also be tapped as an important variable in testing the various explanations currently used to explain lag phenomena found in this study and many other adult lag studies. Our explanation offered here was the most parsimonious for this data; we are not committed to this explanation. Further parametric study with varied stimuli and experimental conditions may help answer that question and other developmental questions like: (a) What is the difference between word and picture processing? (b) What is the story regarding the dual encoding of pictures? (c) What are the different strategies employed in recall and recognition?; and (d) questions regarding buffer capacity, and usage of buffer, with differing stimuli. Currently, we are using this paradigm to study how motivational variables affect encoding strategies.

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TABLE 1

SAMPLE WORD LIST AND LIST STRUCTURE USED IN EXPERIMENT

WORD LIST	LIST POSITION	LIST STRUCTURE*	SECTION
RACE	1.	BUFFER	
GAME	2.	BUFFER	
CENT	3.	BUFFER	
SMILE	4.	LAG 8 (1)	
CAT	5.	FILLER	
LAMP	6.	LAG 2 (1)	
LEG	7.	LAG 0 (1)	
LEG	8.	LAG 0 (1)	
LAMP	9.	LAG 2 (1)	
KEY	10.	LAG 8 (2)	SECTION I
HOP	11.	1P (1)	
TREE	12.	FILLER	
SMILE	13.	LAG 8 (1)	
VILLAGE	14.	LAG 8 (3)	
WOOD	15.	LAG 0 (2)	
WOOD	16.	LAG 0 (2)	
CLEAN	17.	LAG 2 (2)	SECTION II
COTTON	18.	1P (2)	
KEY	19.	LAG 8 (2)	
CLEAN	20.	LAG 2 (2)	
BOOK	21.	LAG 2 (3)	
DAY	22.	LAG 8 (4)	
VILLAGE	23.	LAG 8 (3)	
BOOK	24.	LAG 2 (3)	SECTION III
BED	25.	LAG 0 (3)	
BED	26.	LAG 0 (3)	
SNOW	27.	1P (3)	
PAIL	28.	LAG 0 (4)	
PAIL	29.	LAG 0 (4)	
SHOE	30.	LAG 2 (4)	
DAY	31.	LAG 8 (4)	SECTION IV
ROOM	32.	1P (4)	
SHOE	33.	LAG 2 (4)	
RIDE	34.	FILLER	
DRINK	35.	BUFFER	
BOAT	36.	BUFFER	
BOY	37.	BUFFER	
CHIEF	38.	BUFFER	

*Note: Numbers in parentheses denote lag item numbers. LAG 8 (1), for example, is the first LAG 8 item.

TABLE 2

PREDICTED AND OBTAINED RESULTS FOR EACH EXPERIMENTAL CONDITION

EXPERIMENTAL CONDITION	PREDICTION	OBTAINED RESULTS*
1. Lag 0 - Grades 4, 8, and college	Recall no better than for 1P for each age	No significant differences between 1P and Lag 0 at any age level, $p > .10$
2. Lag 2 - Grade 4	Recall increases over Lag 0	Significant increase in recall between Lag 0 and Lag 2, $p < .01$
3. Lag 8 - Grade 4	Recall at same level as for Lag 2	No significant difference between recall at Lags 2 and 8, $p > .10$
4. Lag 2 - Grade 8 and College	Recall does not increase over Lag 0 levels	No significant difference between recall at Lag 0 and Lag 2, p .10
5. Lag 8 - Grade 8 and College	Recall should increase between Lags 2 and 8	A significant increase in recall between Lags 2 and 8, $p < .02$

*Significance values based on correlated t tests, $df=23$.

FIGURE 1

RECALL AS A FUNCTION OF LAG AND AGE LEVEL